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MICREAgents

Project



RUHR-UNIVERSITÄT BOCHUM

RUB

Microarray of programmable electrochemically active elements

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Possible applications of the MICREAgents Dock,
a two dimensional array of programmable electrochemically active elements,
to Alife.

Device Origin and Design

The dock is a part of a larger project, MICREAgents (McCaskill et. al., 2012). The original vision of the project included two major technological components: lablets and the dock. Lablets are small (~100 x 100 x 50µm), autonomous electronic elements, comprising a form of smart, programmable, electrochemically active 'dust', and unlike conventional smart dust communicating via pairwise interactions rather than wireless radiation. Lablets are poured into a solution, and can interact with the surrounding solution, with each other, and with smart surfaces. A dock is such a static two dimensional array of 256 x 256 microelectrodes (see Fig. 1) beneath a fluid film and connected to a host computer, from which each of the sites may be independently controlled. One goal of MICREAgents was to develop this technology to enable a new form of evolution through the interaction of chemistry with these new hybrid informational-electrochemical elements.

Experimental examples

Electrochemiluminescence (ECL). See Fig.2

Combinatorial galvanic deposition.

Application to ALife

The dock should be useful for novel origin of life experiments, to discover chemistry that enables the transition from nonliving to living matter. A version of the Miller-Urey experiment could be implemented, with the dock's spatial separation and control giving far more experimental range. Redox potentials provide a specific source of energy, and specifically coated electrodes provide a programmable distribution of mineral or organic catalysts that can allow controlled investigation of complex spatially resolved chemical evolution.

The dock is also able to interact in programmable ways with microparticles, including the lablets discussed previously. Such interplay between autonomous programmable mobile electrochemical elements and smart docking surfaces may allow the construction of artificially self-reproducing systems with both electronic and chemical facets, see e.g. (Tangen et al., 2015). Further, McCaskill has proposed electronic genomes that can direct chemistry and are heritable. Wills and McCaskill have conceived the electrochemical equivalent of a genetic code: this time coupling copyable electronic with hard to copy chemical systems, rather than DNA genes and proteins.

The high throughput capabilities of the dock could be further enhanced with fluidic overlays. The simplest possible overlay would simply enable laminar flow of fluid across the dock from one side to another. Standard PDMS microfluidics could create 128 independent channels across the dock.

Portable experimental setup

A portable experimental setup is constructed using a 3D-printed scaffolding with a USB microscope mounted on top of the dock's

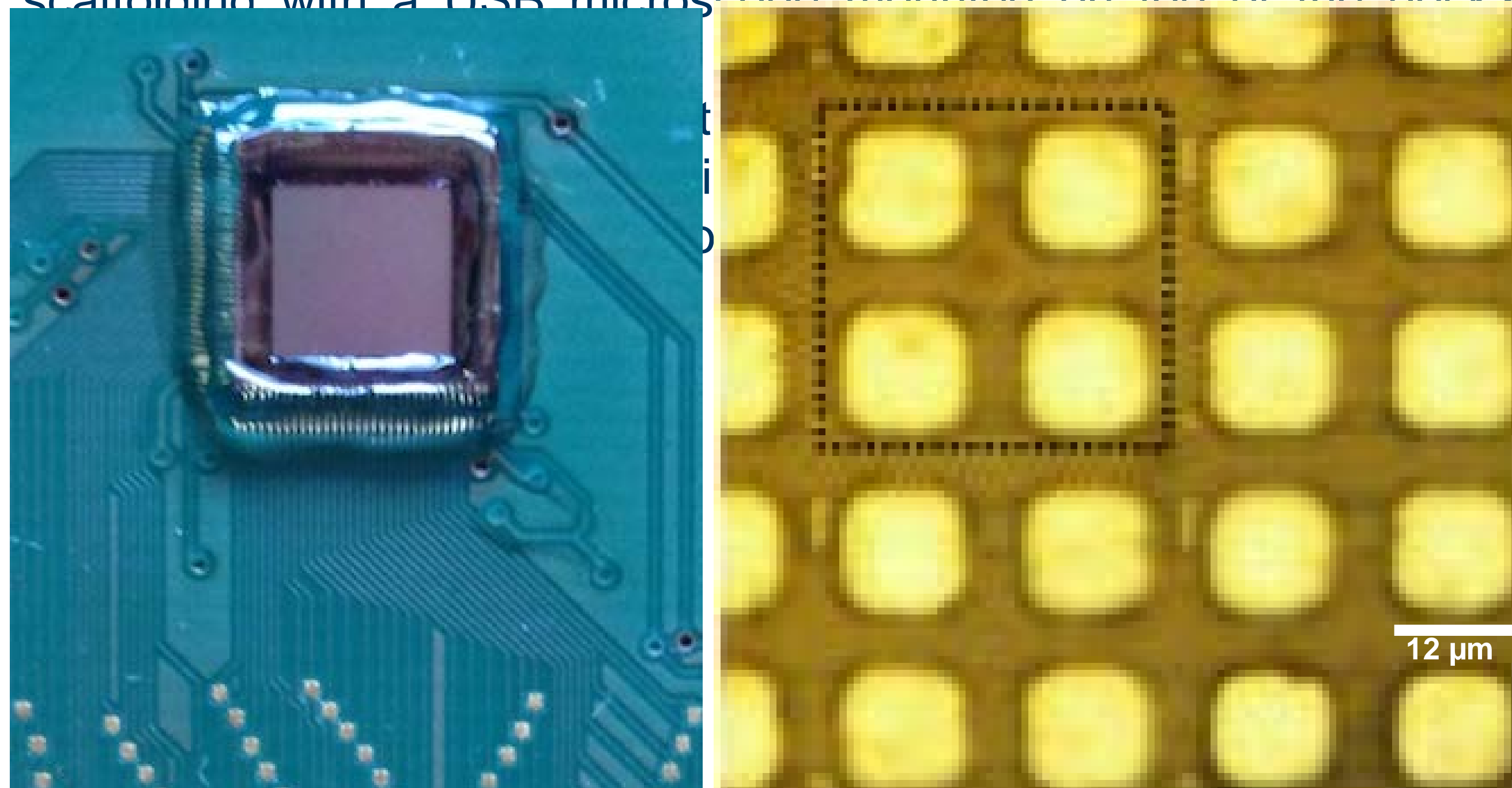


Figure 1. Left: a view of the dock close to actual size (4.6 mm square). Right: A close-up of the dock. A unit cell of the 128 x 128 array contains four electrodes (outlined by the black dotted lines), with a differential sensors and a split actuator.

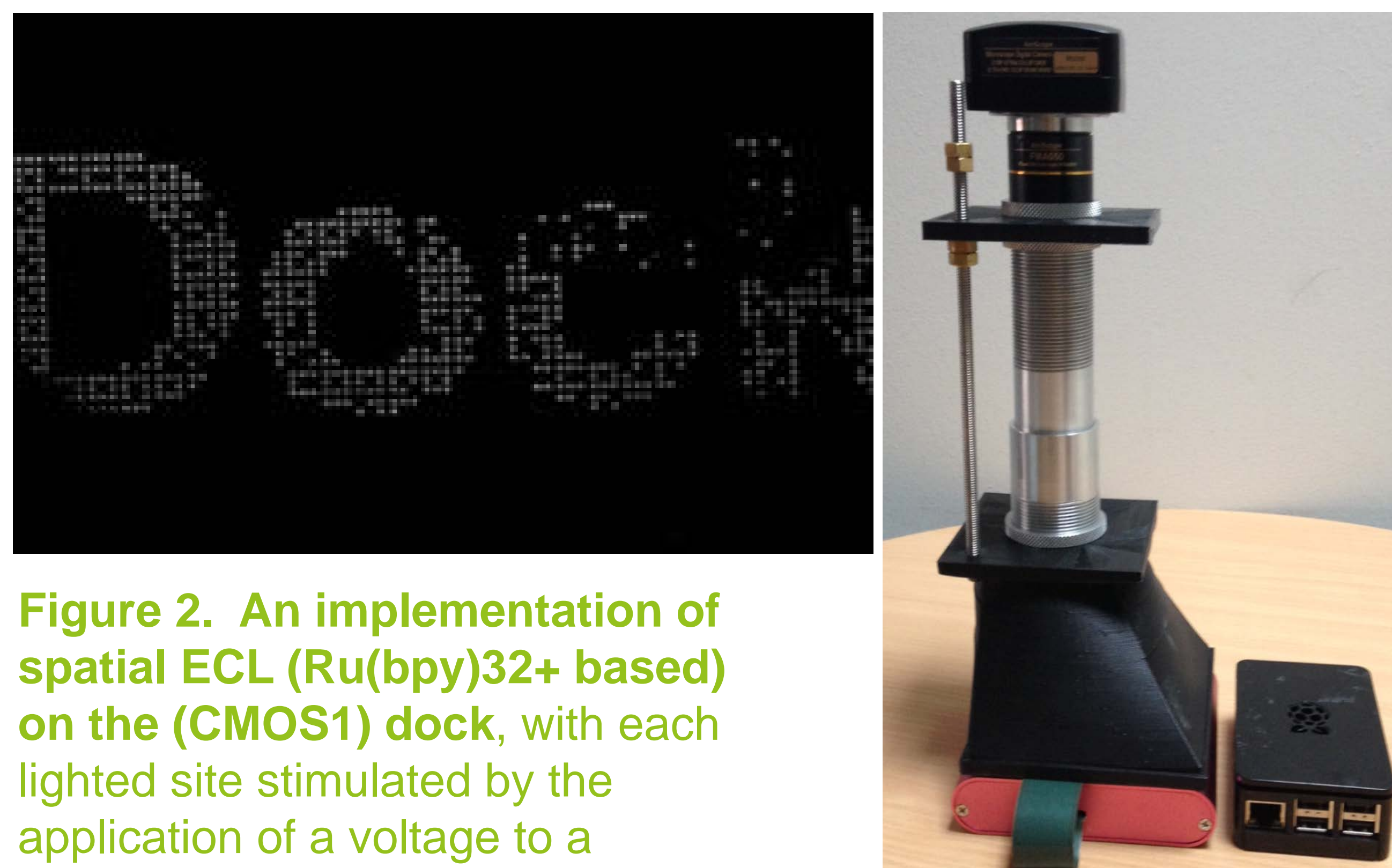


Figure 2. An implementation of spatial ECL (Ru(bpy)₃²⁺ based) on the (CMOS1) dock, with each lighted site stimulated by the application of a voltage to a microelectrode (global counter electrode).

Figure 3. Portable experimental setup for the dock. The microscope camera is mounted atop of an adjustable aluminium tube, mounted onto a 3D printed scaffolding (black - with lights inside), fitted onto a 3D printed dock holder (black), sitting atop of the USB dock-controller box (red). The raspberry pi host computer (running Linux) is shown on the right. Cables are removed for clarity.

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